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Primary comparative assessment of the environmental safety of alternative options for the location of a hazardous industrial facility

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A technology of pre-design comparative assessment of hazardous industrial facilities alternative location options is described in this paper. The technology was designed by the St. Petersburg ecologic and design company Eco-Express-Service LLC. Options' comparison is carried out in two stages using a score/ranking multi-criteria assessment: at first, the determination and comparison of environmental safety criteria, and then – a summary assessment of all set of criteria. 4 competitive methods are used for consolidation of obtained results into general comparative scoring. These methods differ in specification degree of the criteria indicator significance and interrelation of different types of object. Stages of technology application are illustrated with concrete examples. The pre-design comparative assessment technology was tested for alternative options of the Russian section of the Nord Stream 2 offshore gas pipeline and the Complex for processing ethane-containing gas on the territory of the Kingisepp municipal district of the Leningrad region. Main positive effects and advantages of its use are determined by the increase of construction environmental safety and essential economy of the federal, regional and local budgets and investors by eliminating unfavourable object location options at early stages of development.

Keywords: environmental safety, production facility, technology of assessment, criteria, anthropogenic impact.

УДК 504.05

Первичная сравнительная оценка экологической безопасности альтернативных вариантов размещения опасного производственного объекта

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В работе описывается технология предпроектной сравнительной оценки альтернативных вариантов размещения опасных производственных объектов, разработанная санкт-петербургской эколого-проектной компанией «Эко-Экспресс-Сервис». Сравнение вариантов производится на основе многокритериальной балльно-рейтинговой оценки в два этапа: сначала – определение и сравнение значений критериев экологической безопасности, затем – обобщающая сводная оценка по всей совокупности критериев. Для сведения полученных результатов в общую сравнительную балльную оценку используются 4 конкурентных метода, различающиеся степенью детализации учёта индикаторной значимости критериев и соотношения разнотипных участков объекта. Этапы применения технологии проиллюстрированы конкретными примерами. Технология предпроектной сравнительной оценки апробирована для альтернативных вариантов размещения трассы Российского участка морского трубопровода Nord Stream 2 и Комплекса переработки этансодержащего газа на территории Кингисеппского муниципального района Ленинградской области. Основные положительные эффекты и преимущества предлагаемой технологии обусловлены увеличением экологической безопасности строительства и существенной (на порядок величин) экономией средств федерального, регионального и местного бюджета и инвесторов за счёт исключения неблагоприятных вариантов размещения объекта ещё на ранних стадиях проработки.

Ключевые слова: экологическая безопасность, опасный производственный объект, технология оценки, критерии, антропогенное воздействие.

According to standard design cycle scheme, all location options are comprehensively considered and compared within the typical environmental project documentation [1, 2]. According to Decree of the Russian Government of 16 February 2008 No. 87 "Regulation on composition of design documentation sections and requirements to their contents" (paragraph 25), section 8 "Environmental Protective Measures Plan" should contain results of capital construction impact assessment on the environment. At the same time, according to the "Regulations on environment impact assessment in Russian Federation" (approved by the Order of the State Committee on Ecology of the Russian Federation of 16 May 2000 No. 372), during this assessment it is necessary to determine and consider the expected environmental impact of several alternative object locations and justify the choice of the best option (paragraphs 1.6, 2.4, 3.2.2, 4, 5, 11). The Order of the State Committee on Ecology of the Russian Federation of 16 May 2000 No. 372 is not applicable since 01.09.2021, however, the coming into force the Order of the Ministry of Natural Resources and Environment of the Russian Federation dated 01.12.2020 No. 999 "On approval of requirements for environmental impact assessment materials", instead of previous Order, retains the requirement to assess the expected environmental impact of several alternative options for the location of hazardous industrial facilities (with an justification for choosing the best option).

Thus, it is necessary to consider several alternative options for the implementation of planned activity (including the choice of facility location) and to develop the project documentation for each of option, including its environmental components [3, 4]. Accordingly, a full expensive and time-consuming complex of measures is carried out for all, even the most dangerous location options: multifaceted engineering surveys are carried out, then environmental impact assessment (EIA) is carried out on their basis, and taking into account its results environmental protective design measures are developed and etc. [1, 5–7].

The purpose of this work is to present the technology of pre-design comparative environmental assessment of hazardous industrial facilities alternative options, which allows to eliminate the least environmentally friendly options for locating hazardous industrial facilities at the earliest design stage, with minimum labour input, cost and time consumption.

Accordingly, publication problems are: 1) comparative assessment method description; 2) analysis of its main advantages, novelty and positive effects; 3) some information about approbation.

Materials and methods

The technology of pre-design comparative assessment of hazardous industrial facilities alternative options was designed by the St. Petersburg ecologic and design company "Eco-Express-Service" LLC [8, 9]. The following original databases served as the material for its creation:

1. Database "Database for hydraulic works' impact assessment on ecosystems of inland sea and territorial waters in the Russian Federation, 2001–2019", which is registered by Federal Service for Intellectual Property (Rospatent) [10]. It includes detailed characteristics of anthropogenic impacts on the environment for more than 300 projects.

2. Database "Coastal ecosystems of inland sea waters and territorial sea of the Russian Federation", also registered by Rospatent [11]. The database includes hydrological and hydrochemical indicators and indexes, value characteristics of aquatic and terrestrial ecosystems, bottom soils and coastal areas' soils, macrophytes, phytoplankton, zooplankton, zoobenthos, ichtyocoenosis communities, seafowl, waterfowl and semiaquatic birds, marine mammals, terrestrial semiaquatic biota.

Two examples of choosing the location of hazardous industrial facilities are used for demonstration of technology:

1) A comparative environmental assessment of two alternative options for the Russian section

of the Nord Stream 2 offshore gas pipeline (the customer is Nord Stream 2 AG, 2016).

The Nord Stream 2 project [12] provides the construction of two offshore gas pipelines with a total capacity of 55 billion m^3 of gas per year from Russia to Germany along the bottom of the Baltic Sea. The gas pipeline route is planned to pass through the territorial waters or the exclusive economic zones of Russia, Finland, Sweden, Denmark and Germany. In 2015–2016 "Eco-Express-Service" LLC has executed a comparative environmental assessment of two alternative options for the Russian section route of the gas pipeline with different approaches to the marine area: through the Kurgalsky peninsula (the "Narva Bay" option); through the Kolganpya cape at the Soikinsky Peninsula (the "Kolganpya" option).

The endpoints of these alternative routes coincide and are located on the border of the Russian territorial waters and the Finnish exclusive economic zone.

2) Comparative environmental assessment of three alternative options of location the Complex for processing ethane-containing gas on the territory of the Kingisepp municipal district of the Leningrad region (the customer is "SRDI OG "PETON" LLC, 2018) [13].

The complex for processing ethane-containing gas near Ust-Luga seaport includes a gas processing plant, a gas-chemical plant, a gas-chemical complex and utilities, infrastructure and offsites. Main pipelines construction of feedstock gas and methane fraction (DN1400, PN10 MPa) in one technical corridor is provided. A comparative multicriteria assessment of two Complex options was carried out according to the following variants:

– option 1 – a site near gas-compressor station "Slavyanskaya" (Ust-Luga rural settlement), 700 ha;

– option 2 – a site on lands of the Ust-Luga Multimodal Complex (Vistino rural settlement). According to this option, two Complex configurations of 715 ha and 780 ha were compared.

– option 3 – a site on lands of Ust-Luga Industrial Park, 865 ha.

Information support for comparing location options according to the technology being presented required the determination of corresponding criteria values. Short-term targeted selective engineering surveys (mainly environmental) were conducted for this purpose. All researches within these surveys were conducted in full accordance with standard regulatory requirements.

Results and discussion

Technology for comparative assessment of environmental safety of hazardous industrial facilities alternative location options

Comparative assessment of object location alternative options is carried out in two stages.

Stage 1. Determination of environmental safety criteria values and their comparative analysis. Comparative assessment of environmental safety of object location alternative options is based on a criteria system characterizing both various components of the environment and technical and technological objects' differences. As the criteria system is focused on identification and quantification of dangerous and harmful effects on the environment, positive externalities of object construction and operation are not directly taken into account in calculations.

At the first stage:

– testing of potential criteria (selection of such criteria for which empirical values can be determined with equal degree of representativeness);

– determination of empirical values for criteria that have successfully passed the test.

Criteria. The number of criteria considered, depending on the object nature and environment characteristics, varies from 230 to 400.

The whole set of criteria is divided into five criteria groups: group No. 1 – technical and technological options' differences; group No. 2 – environmental restrictions; group No. 3 – initial state of the environment; group No. 4 – environmental impact; group No. 5 – characteristics of possible accidents.

An example of criteria group No. 1 and comparison of their values for two route options of Nord Stream 2 gas pipeline is given in Table 1.

Stage 2. Unifying score/ranking multiple-criteria comparative assessment. Four competitive methods were used in order to combine the results obtained into an overall comparative score – Eq. (1–4).

1. Scoring which does not involve weighting factors for the criteria, or the results of object zoning (X_1).

2. Scoring involving weighting factors for all the criteria but not the results of object zoning (X_2).

3. Scoring which does not involve weighting factors for the criteria but involves the results of object zoning (X_3).

4. Scoring which involves weighting factors for all the criteria and the results of object zoning (X_4).

Table 1

Criteria group No. 1 and an example of comparing their values
(for two route options of Nord Stream 2 gas pipeline)

Comparative assessment criterion	Units	"Narva Bay" option (N)	"Kolganpya" option (K)	Ratio (N/K)	Option preference
Total length of the Russian part of the route	m	118000	156700	0.75	N
Length of onshore part of the route	m	4000	750	5.71	K
Length of offshore part of the route	m	114000	156000	0.73	N
Length of a coastal trench	km	3.9	1.6	2.44	K
Depth of pipeline output to a seabed surface	m	12.7	17.5	0.73	N
Area of a temporary cofferdam	m^2	41000	29725	1.38	K
Volume of coastal dredging	m^3	425000	354000	1.2	K
Volume of additional dredging near zones of military activity	m^3	240000	2400000	0,1	N
Volume of additional dredging for protection against ice gouging and vessel grounding	m^3	0	320000	0	N
Volume of additional dredging for protection at route crossing points with East and West navigation canals	m^3	0	1680000	0	N
Total volume of dredging	m^3	**665000**	**4754000**	**0.14**	N
Volume of rock dumping for flattening of pipe buckling (preliminary assessment)	m^3	900000	1011000	0.89	N
Volume of rock dumping for correction of unsupported width	m^3	180000	300000	0.6	N
Volume of stone and gravel berm next to vessel anchorage 10A	m^3	0	70000	0	N

Note: A full example of technology using for comparing two route options of Nord Stream 2 is presented in a scientific report of "Eco-Express-Service" LLC, which is in free access on the website of Nord Stream 2 AG [14].

Summary assessment using methods No. 3 and 4 provides relatively discrete and quality-specific zonation of future natural and technical system within the planned object area. The nature of expected object impact and the environment state vary significantly less within these zones than outside. Accordingly, a structure of all imperative factors within the object area is relatively constant, and a set of all considered criteria with high indicator weights ($W = 4–5$) is almost the same.

The simplest examples of such zonation are:

– separation of the main gas pipeline route into offshore and onshore sections (Nord Stream 2 gas pipeline route) [14];

– separation of the production facility territory into areal and linear sections (Complex for processing ethane-containing gas near Ust-Luga seaport).

The resulting estimates (by the methods No. 1–4) are given according to the formulas with corresponding numbers:

$$X_1 = N, \quad (1)$$

$$X_2 = \sum_{i=1}^{N} W_i \quad (2)$$

$$X_3 = \sum_{j=1}^{m} \left(\frac{S_j}{S} \cdot n_j \right) \quad (3)$$

$$X_4 = \sum_{j=1}^{m} \left(\frac{S_j}{S} \cdot \sum_{k=1}^{n_j} W_k \right), \quad (4)$$

where N – total number of criteria that gives one option the edge over alternative options with regard to the entire object area as a whole (without zoning);

W – weighting factor of a criterion characterizing its indicator significance according to a five-point scale ($W = (1, \ldots, 5)$) (it is awarded to all criteria by expert groups of specialists);

W_i – weighting factor of the i^th^ criterion that gives one option the edge over alternative options with regard to the entire object area as a whole (without zoning) ($i = (1, \ldots, N)$);

Table 2

An example of unifying score/ranking multiple-criteria comparative assessment
(for two route options of Nord Stream 2 gas pipeline)

Assessment method, No.	"Narva Bay" option (N) (points)	"Kolganpya" option (K) (points)	Ratio (N/K)	Option preference
1	213	109	1.95	N
2	877	408	2.15	N
3	182	77	2.36	N
4	758	290	2.61	N

m – number of different object zones that are characterized by essentially different nature of the impact on the environment and (or) are located in contrasting environmental conditions;

n_j – total number of criteria that gives one option the edge over alternative options in j-zone (k = (1, ..., n_j));

W_k –weighting factor of the k[th] criterion that gives one option the edge over alternative options in j-zone (k = (1, ..., n_j));

s_j – j-zone area (j = (1, ..., m));

S – total area of the object $(S = \sum_{j=1}^{m} S_j)$.

All alternative options are compared in pairs for each of four indicators (X_1, ..., X_4) and the best options predominance multiplicity over the others is compared. The maximum predominance multiplicity is compared according to X_1, ..., X_4 indicators and a general conclusion is given.

An example of unifying score/ranking multiple-criteria comparative assessment for two route options of Nord Stream 2 gas pipeline is given in Table 2.

It is clear that final scoring for both options varies slightly depending on the comparison method used. The differences in assessment are least striking when using the simplest method of adding up points but not involving the indicator value of every criteria. Involving the differences in the diagnostic values of the criteria and using weighting factors significantly and results of object zoning improves the resolution of the comparison, as the differences in scores noticeably increase. Nevertheless, the choice of preferable option is the same for any of four alternative methods.

Main advantages and positive effects of application the technology of pre-design comparative assessment of hazardous industrial facilities alternative options

The technology makes possible to identify the safest production facility location options at the early design stages and to give a quantitative environmental assessment of compared options. These are main advantages and novelty of the technology.

Much less complete and much faster, selective targeted engineering surveys are required for criteria selection and determination of their values. Their results are also processed according to a simplified brief scheme. As a result, the worst, most environmentally hazardous location options are rejected at the earliest design stage, with minimum labour input, time consumption and financial costs. And only the best options, which have been preliminary selected, undergo a full procedure of design cycle.

Expected economic, social and other positive effects of using this technology are caused:

– by an increase in the environmental safety of transport and industrial construction;

– by substantial (by an order of values) cost savings of federal, regional and local budget and investors, that are being spent for justification of the transport and production facilities' location choice, for their design and construction;

– by obvious positive externalities of transport and industrial system safe development for the region population and, accordingly, by minimization of technogenic impact and its negative effects.

Particularly, the effect of cost savings, spent for planned objects design, is determined by the following components:

1) Prevention of meaningless costs for design study of environmentally hazardous options for object location. It is caused by an accelerated rejection of the worst options based on the minimum set of engineering survey results, necessary and sufficient to determine the criteria values. The cost of a full cycle of environmental works within the hazardous industrial facilities design decreases by an order of values (more accurate decrease of this cost depends on initial quantity of planned alternative location options of a particular hazardous industrial facility, on characteristics of the facility and the environment).

This statement can be briefly illustrated by a particular recent example. "Eco-Express-

Service" LLC has executed a work "Comparative environmental assessment of alternative location options for Complex for processing ethane-containing gas on the territory of the Kingisepp municipal district of the Leningrad region" in 2018 by order of "SRDI OG "PETON" LLC. Three object location options at different places were compared.

The work has been done using the considered technology of multi-criteria assessment.

One of the options, which has obvious advantages over the others in considerably greater environmental safety (option No. 1, a site near gas-compressor station "Slavyanskaya"), has been selected and recommended according to work results. The price of all these works was 2,0 million rubles (hereinafter, when analyzing the example, the prices are indicated in according with the work period (2018)). The price of standard engineering surveys for all three alternative options (the area of three sites was 700 ha, 780 ha and 715 ha) would be in total not less than 22 million rubles (7.0, 7.8 and 7.2 million rubles respectively). Development of only one set of environmental project documentation (environmental protective measures plan, including the results of environment impact assessment) for each of these three options would have cost at least 2 million rubles, in total it is not less than 6 million rubles. So, the cost of engineering surveys and preparing an environmental project documentation would be 9–10 million rubles for one of alternative options, that is 27–30 million rubles for all three options. Therefore, the cost of comparative assessment of alternative location options using the considered multi-criteria assessment technology turned out to be 13–15 times less than using the traditional design cycle scheme.

2) Besides, it is also necessary to take into account a substantial prevented damage to various components of the environment and society caused by a fast rejection of the riskiest options of object construction. The reality is that, the risk of accidents during hazardous industrial facilities' construction and operation (and, therefore, the associated environmental and economic damage) can be reduced several times – from 2 to 5 due to the technology of preliminary multicriteria comparative assessment.

3) Finally, the effect of preventable damage to human health (including its economic equivalents) can also be additionally taken into account due to well-timed prevention of potential impact of hazardous and harmful production factors justified by this technology.

Technology approbation

The technology considered is certified against the regulatory requirements (certificate of conformity No. FSK.RU.0002.F0005798 of the Federal Technical Regulation and Metrology Agency (Rosstandart)). Positive expert reviews of Institute of Geography RAS and Peter the Great St. Petersburg Polytechnic University were given. There are positive reviews of design works' customers (from Nord Stream 2 AG (Nord Stream-2 gas pipeline), from "SRDI OG "PETON" LLC (Complex for processing ethane-containing gas) etc.). The technology was awarded the third prize at the International Competition of scientific, technical and innovative developments aimed at the development of the Arctic and continental shelf with the assistance of the Russian Federation Government and the Ministry of Energy of the Russian Federation in 2018. The evidence of competence to use this technology is also positive state environmental expert review and state expertise approval for the Nord Stream 2 gas pipeline construction (the Russian section).

The validity of this technology application is also evidenced by the environmental seal of approval and favourable conclusion of RF State Expert Evaluation Department on the project of Nord Stream 2 gas pipeline (Russian section) construction. Results of a project cycle confirmed the preliminary result of the gas pipeline dislocation options comparing, obtained based on the technology presented here. The Narva Bay option was selected and implemented. At present, the offshore section of the first gas pipeline string of Nord Stream 2 has been technically completed. A pipelay was completed and gas pipeline offshore sections placed from the Russian and German sides were interconnected in 2021. Pipe-laying works on the offshore section of the second gas pipeline string are continuing now [15].

The decision on the final configuration of complex project for processing ethane-containing gas was made in March 2019. The results of a detailed comparative environmental assessment of Complex location alternative options also fully confirmed the conclusion made initially based on the presented technology in favor of option No. 1 (a site near gas-compressor station "Slavyanskaya" (Ust-Luga rural settlement). The project received a favourable conclusion of RF State Expert Evaluation Department [16]. Gazprom and RusGazDobycha began the complex construction in May 2021 [17].

Therefore, this technology application turned out to be effective in choosing alternative options, and the final decision on hazardous industrial facilities location coincided with the results of the comparative environmental assessment of alternative options. This illustrates the applicability of the proposed technology for a comparative express assessment of the possible hazardous industrial facilities location options to other similar objects.

Conclusion

Therefore, the technology considered significantly simplifies, speeds up and makes cheaper the procedure of comparative environmental assessment of various location options for production facilities.

At the same time, economic, social and other positive effects are caused by a decrease in the environmental risk of hazardous industrial facilities' construction and operation, as well as substantial (by an order of values) savings of costs and time, spent for choosing location option.

Main application scopes of the technology are: industrial and transport construction and design; assessment and regulation of industrial and transport facilities' environmental impact; territorial and marine spatial planning.

References

1. Khovavko I.Yu. Environmental Impact Assessment: Russian and International experience // Moscow University Economics Bulletin. 2010. Series 6. Economics. No. 4. P. 96–111 (in Russian).

2. Kamdina L.V. Environmental imperative of modernization of nature-intensive industries // Bulletin of Chelyabinsk State University. Series Economics. 2011. No. 35 (251). P. 75–80 (in Russian).

3. Mylarshchikov A.M. Systematization of anthropogenic impact on the environment assessing methods // Internet-journal "Naukovedenie". 2012. No. 3. P. 1–18 (in Russian).

4. Kharitonov G.B. Analysis of methodologies and techniques for assessing environmental damage from negative anthropogenic impact on the environment // Problems of modern economics. 2010. No. 1–2. P. 27–31 (in Russian).

5. Environmental Impact Assessment of Projects. Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/92/EU as amended by 2014/52/EU). European Union, 2017. 130 p.

6. Guidance on EIA Scoping. Luxembourg: Office for Official Publications of the European Communities. European Commission, 2001. 35 p.

7. Lokhov A.S., Gubaidullin M.G., Korobov V.B., Tutygin A.G. Geographical and ecological land zoning of onshore oil pipeline location by level of hazard to environment from emergency oil spills in Arctic region // Theoretical and Applied Ecology. 2020. No. 4. P. 43–48 (in Russian). doi: 10.25750/1995-4301-2020-4-043-048

8. Zhigulsky V.A., Shuisky V.F., Shchashchaev Y.A., Bylina T.S. "Eco-Express-Service" LLC: experience in the assessment and forecasting of impacts on aquatic ecosystems at hydroconstruction // Fishery protection in Russia. 2011. No. 2 (6). P. 42–47 (in Russian).

9. Zhigulsky V.A., Shuisky V.F., Maximova T.V., Maximova E.Yu. Quantitative estimation of anthropogenic environmental risk (by the example of tasks of marine spatial basing) // Ecology and Industry of Russia. 2014. No. 8. P. 40–43 (in Russian).

10. Zhigulsky V.A., Shuisky V.F., Chebykina E.Yu. Database for hydraulic works' impact assessment on ecosystems of inland sea and territorial waters in the Russian Federation, 2001–2019 // Certificate of the database state registration No. 2020620240, 10.02.2020. Registration form No. 2019622362, 11.12.2019 (in Russian).

11. Zhigulsky V.A., Shuisky V.F., Chebykina E.Yu., Zhigulskaya D.V. Coastal ecosystems of inland sea waters and territorial sea of the Russian Federation // Certificate of the database state registration No. 2020622836, 29.12.2020. Registration form No. 2020622660, 14.12.2020 (in Russian).

12. Official website of Nord Stream 2 AG – Saint-Petersburg, Background Story. Pipeline Construction. Nord Stream 2 AG. 2019 [Internet resource] https://www.nord-stream2.com/en/pdf/document/180/ (Accessed: 02.08.2021).

13. Official website of Gazprom. Decision made to implement major gas processing and liquefaction project near Ust-Luga. Gazprom 2019 [Internet resource] https://www.gazprom.com/press/news/2019/march/article477709/ (Accessed: 02.08.2021).

14. Official website of Nord Stream 2 AG – Saint-Petersburg, 2016. Comparative environmental assessment of route options Nord Stream 2 offshore pipeline, Russian Section. "Eco-Express-Service" LLC [Internet resource] https://www.nord-stream2.com/ru/pdf/document/86/ (Accessed: 02.08.2021) (in Russian).

15. Official website of Nord Stream 2 AG. The Offshore part of one line of Nord Stream 2 has been mechanically completed [Internet resource] https://www.nord-stream2.com/media-info/news-events/the-offshore-part-of-one-line-of-nord-stream-2-has-been-mechanically-completed-149/ (Accessed: 02.08.2021).

16. Official website of Information & Analytical Agency PortNews. Complex for processing natural oil gas in Ust-Luga was approved by FAI Glavgosexpertiza [Internet resource] https://portnews.ru/news/310396/ (Accessed: 02.08.2021) (in Russian).

17. Official website of Gazprom. Construction begins on Complex for processing ethane-containing gas near Ust-Luga [Internet resource] https://www.gazprom.com/press/news/2021/may/article529200/ (Accessed: 02.08.2021).